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Effect of Ebola virus disease on maternal and child health services in Guinea: a retrospective observational cohort study

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Summary

Background—The 2014 west African epidemic of Ebola virus disease posed a major threat to the health systems of the countries affected. We sought to quantify the consequences of Ebola virus disease on maternal and child health services in the highly-affected Forest region of Guinea.

Methods—We did a retrospective, observational cohort study of women and children attending public health facilities for antenatal care, institutional delivery, and immunisation services in six of seven health districts in the Forest region (Beyla, Guéckédou, Kissidougou, Lola, Macenta, and N’Zérékoré). We examined monthly service use data for eight maternal and child health services indicators: antenatal care (1 antenatal care visit and 3 antenatal care visits), institutional delivery, and receipt of five infant vaccines: polio, pentavalent (diphtheria, tetanus, pertussis, hepatitis B virus, and *Haemophilus influenzae* type b), yellow fever, measles, and tuberculosis. We used interrupted time series models to estimate trends in each indicator across three time periods: pre-Ebola virus disease epidemic (January, 2013, to February, 2014), during-epidemic (March, 2014, to February, 2015) and post-epidemic (March, 2015, to Feb, 2016). We used segmented

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Contributors

AD, AMEA, SDS, and TD conceived the research question and developed the protocol. AD, SDS, BSC, and AHB oversaw study implementation. AD and AMEA were responsible for the data analysis and the writing of the first draft of the manuscript. TD, JO, GWR, W-HZ, and VDB assisted with development of the study design, data analysis, data interpretation, and critical review of the manuscript. All authors read and approved the final manuscript.

Declaration of interests

We declare no competing interests.

See Online for appendix

ordinary least-squares (OLS) regression using Newey-West standard errors to accommodate for serial autocorrelation, and adjusted for any potential effect of birth seasonality on our outcomes.

Findings—In the months before the Ebola virus disease outbreak, all three maternal indicators showed a significantly positive change in trend, ranging from a monthly average increase of 61 (95% CI 38–84) institutional deliveries to 119 (95% CI 79–158) women achieving at least three antenatal care visits. These increasing trends were reversed during the epidemic: fewer institutional deliveries occurred (–240, 95% CI –293 to –187), and fewer women achieved at least one antenatal care visit (–418, 95% CI –535 to –300) or at least three antenatal care visits (–363, 95% CI –485 to –242) per month ($p<0.0001$ for all). Compared with the negative trend during the outbreak, the change in trend during the post-outbreak period showed that 173 more women per month (95% CI 51–294; $p=0.0074$) had at least one antenatal care visit, 257 more (95% CI 117–398; $p=0.0010$) had at least three antenatal care visits and 149 more (95% CI 91–206; $p<0.0001$) had institutional deliveries. However, although the numbers for these indicators increased in the post-epidemic period, the trends for all stagnated. Similarly, the increasing trend in child vaccination completion during the pre-epidemic period was followed by significant immediate and trend reductions across most vaccine types. Before the outbreak, the number of children younger than 12 months who had completed each vaccination ranged from 5752 (95% CI 2821–8682) for tuberculosis to 8043 (95% CI 7621–8464) for yellow fever. Immediately after the outbreak, significant reductions occurred in the level of all vaccinations except for yellow fever for which the reduction was marginal. The greatest reductions were noted for polio and tuberculosis at –3594 (95% CI –4811 to –2377; $p<0.0001$) and –3048 (95% CI –5879 to –216; $p=0.0362$) fewer vaccines administered, respectively. Compared with pre-Ebola virus disease outbreak trends, significant decreases occurred for all vaccines except polio, with the trend of monthly decreases in the number of children vaccinated ranging from –419 (95% CI –683 to –155; $p=0.0034$) fewer for BCG to –313 (95% CI –446 to –179; $p<0.0001$) fewer for pentavalent during the outbreak. In the post-Ebola virus disease outbreak period, vaccination coverage for polio, measles, and yellow fever continued to decrease, whereas the trend in coverage for tuberculosis and pentavalent did not significantly differ from zero.

Interpretation—Most maternal and child health indicators significantly declined during the Ebola virus disease outbreak in 2014. Despite a reduction in this negative trend in the post-outbreak period, the use of essential maternal and child health services have not recovered to their pre-outbreak levels, nor are they all on a course that suggests that they will recover without targeted interventions.

Introduction

Over the past decade, substantial progress has been made in reducing maternal mortality and increasing access to maternal and reproductive health care globally.¹ However, the recent Ebola virus disease epidemic, centred in Guinea, Liberia, and Sierra Leone, has been a major threat to the lives of mothers and infants in west Africa, not only through the high mortality rate among the individuals who became infected, but also indirectly through halting preventive and emergency obstetric care and immunisation programmes.^{2–5} Health-care workers deserted already understaffed health facilities because of fears of becoming infected and dying from Ebola virus disease, especially because of the absence of adequate

personal protective equipment and inadequate training.^{6,7} From a health-service user perspective, care-seeking behaviours for both emergency and preventive health-care services, including antenatal care and childhood vaccination, might have changed from fear of contracting the virus.^{8,9} Additionally, community mistrust of the health system might have amplified cultural differences between biomedical needs and the social context,^{9,10} contributing to reductions in use of available health services.

The effect of the Ebola virus disease outbreak on maternal and child health has already been considered from a theoretical perspective, highlighting the fragility of the affected health systems and the vulnerability of mothers and children.^{2,3,5,11} In rural Guinea, significant reductions in unmet obstetric needs, including antenatal care, normal delivery, and caesarean delivery, were being achieved with the 2010 introduction of free obstetric care in all public health facilities;¹² however, the collateral disruption of these nascent improvements in services and the social fractures described above presented a substantial challenge to recovering and surpassing the previous progress in maternal and child health outcomes. For children younger than 5 years, an age group at particularly high risk of malaria morbidity and mortality, significant reductions in all-cause patient visits, fever cases, and malaria cases were noted in Guinean health facilities during the Ebola virus disease epidemic compared with data from 1 year previously,¹³ which contributed to thousands of preventable deaths associated with an absence of treatment.¹⁴

Although field data are needed to better understand this effect and generate evidence-based guidance for stakeholders, reports from only a few studies have given such data. Ribacke and colleagues¹⁵ reported a greater than 20% decrease in the number of institutional deliveries and caesarean deliveries during the Ebola virus disease outbreak in Sierra Leone, mainly because of the closure of not-for-profit hospitals. Findings from studies in Liberia and Guinea confirmed a similar decrease in institutional deliveries and in-hospital admissions during the outbreak compared with periods before the outbreak.^{16–19} However, these studies have not been able to provide sufficient trend information about maternal and child health services before, during, and after the Ebola virus disease outbreak because almost all the existing studies ended during the epidemic or immediately after it. Consequently, there is a shortage of data about the resumption of services after the epidemic. Additionally, the outbreak manifested itself differentially across the three countries; while Sierra Leone and Liberia had country-wide epidemics, the pattern of disease in Guinea differed across its natural regions.

The Ebola virus disease outbreak officially ended on Dec 29, 2015, in Guinea, with a total of 3351 laboratory confirmed cases recorded during the outbreak and a case fatality rate of 62%.²⁰ Although 26 of 34 country-wide health districts reported cases of Ebola virus disease, the Forest region alone accounted for 44% of all cases, despite representing only 22% of the country's population.^{21,22} As Guinea starts its recovery, there is a need to quantify the impact of the outbreak on specific maternal and child health services to inform and support post-Ebola programmes and to guide long-term strategies for optimising high-quality maternal and child health services. These objectives are particularly important for supporting Guinea's progress towards reducing maternal mortality.^{23,24} Thus, the objective of our study was to assess maternal and child health, and more specifically use of antenatal

care, institutional delivery, and immunisation services, before, during, and after the Ebola virus disease outbreak in the highly affected Forest region of Guinea.

Methods

Study design and setting

We did a retrospective, observational cohort study, which reviewed routine service data. The Forest region, a forested, mountainous area in southeastern Guinea, was the region first and most severely affected by the Ebola virus disease outbreak. It includes the N'Zérékoré administrative region and the district of Kissidougou and shares borders with Liberia and Sierra Leone (figure 1). The first case of Ebola virus disease in Guinea was officially reported within this region in March, 2014.

For the purpose of this study, we considered six of the seven health districts in the Forest region (Beyla, Guéckédou, Kissidougou, Lola, Macenta, and N'Zérékoré). One district (Yomou) was excluded because of poor availability and incompleteness of data. The six districts include one regional hospital, five district referral hospitals, two community hospitals, and 38 health centres, serve a population of 1 747 400 inhabitants (94% of the region's population), and reported 1676 cases of Ebola virus disease (99% of the region's Ebola virus disease burden). These districts accounted for 56 of the 58 infections in health-care workers reported in the region. Only referral and community hospitals are capable of performing surgery and transfusions, including caesarean sections. Since Feb 25, 2015, no new case of Ebola virus disease has been reported from the Forest region.²¹ Ethics approval was obtained from the Faculty of Medicine of the Gamal University of Conakry and the National Ethics Committee for Health Research of Guinea.

Study population

The study population was women and children attending public health facilities for antenatal care, institutional delivery, and immunisation services in the six study districts. Table 1 presents some estimates of the population served by each of the health districts within our study, including the overall population, number of children younger than 12 months, and the target number of females for antenatal care services, established by the Guinean Ministry of Health.

Maternal and child health services in Guinea

In Guinea, maternal and child health services are integrated into the primary health-care services. However, in 2012, modern contraceptive prevalence was low (6%) with a concurrent high fertility rate (5.1 children per woman) and high maternal mortality (724 deaths per 100 000 livebirths).²⁵ Only 16% of health professionals (doctors, state midwives, and state nurses) work in rural areas where they serve 65% of the population.²⁶ Between 2007 and 2012, about 59% and 55% of births in the country, respectively, occurred at home and were assisted by unskilled birth attendants.²⁵

In Guinea, antenatal care and vaccination services are provided at several levels to maximise coverage. Approximately 60% of antenatal care and vaccination services occur through a

facility-based fixed strategy and 40% occur within the community via outreach services. Most vaccination occurs routinely at health facilities with additional vaccine campaigns occurring periodically mainly for polio and measles. In 2013 (before the Ebola virus disease outbreak), three polio vaccine mass campaigns were undertaken within the study region, followed by four campaigns between March, 2015, and January, 2016, (after the Ebola virus disease outbreak). No mass vaccine campaigns were done during the Ebola virus disease outbreak within the study region. Additionally, one anti-measles and one anti-meningitis vaccine mass campaigns were done respectively before and after the Ebola virus disease outbreak within the region.

Data collection

We extracted data for monthly facility-based maternal and child health services use from all health facilities located in the six health districts for the period January, 2013, to March, 2016. Indicators on the use of maternal and child health services were the number of antenatal care visits by women and whether the woman delivered their baby in an institution. Indicators on the use of immunisation services were the number of children younger than 12 months who had completed their polio vaccination schedule (three doses), pentavalent vaccine schedule (three doses: combined *Haemophilus influenzae* type b [Hib]; diphtheria, tetanus, and pertussis [DTP]; and hepatitis B virus [HBV]), yellow fever (anti-amaril vaccine), measles (Rouvax vaccine), and BCG (anti-tuberculosis vaccine). We extracted data using standardised data abstraction forms from paper registers at each facility. To ensure data quality, we compared the abstracted data with aggregated data from monthly reports submitted by each health facility to the district health office. Data collectors (final-year medical students) were trained and were unaffiliated with the facilities. The data were extracted over the period July 1, 2015, through Aug 15, 2016.

Statistical analysis

We assessed the effect of the Ebola virus disease epidemic on the use of maternal and child health services focused on the eight chosen indicators through compiling the existing data across the six health districts and estimating a sequence of interrupted time series models, one for each distinct indicator, across three periods: before the Ebola virus disease epidemic (January, 2013, to February, 2014), during the epidemic (March, 2014, to February, 2015), and after the epidemic (March, 2015, to February, 2016). The distinct periods reflect the epidemic as experienced within the Forest region. We used segmented ordinary least-squares regression using Newey-West standard errors to accommodate for serial autocorrelation,^{27,28} and adjusted for any potential effect of birth seasonality on our outcomes. The interrupted time series regression model followed the format:

$$Y_t = \beta_0 + \beta_1 T_t + \beta_2 X_t + \beta_3 X_t T_t + \beta_4 Z_t + \beta_5 Z_t T_t + \beta_m \text{Month} + \epsilon_t$$

where β_0 estimates the number of individuals using the service at the beginning of the pre-outbreak period, β_1 estimates the average monthly change in the number using the service over the pre-outbreak period, T_t is the time since the start of the study, β_2 represents the change in the level of service use that occurred in the period immediately after the Ebola

virus disease outbreak (outbreak period designated by indicator variable X_t), β_3 represents the difference between the trend in service use during the Ebola virus disease outbreak compared to the pre-disease period, β_4 represents the change in service use that occurred in the period immediately after the end of the outbreak (post-outbreak period designated by indicator variable Z_t), β_5 represents the difference between the trend in service use during the period after the Ebola virus disease outbreak compared with the period during the outbreak period, β_m represents a series of indicator variables for calendar month, and ϵ_t the random error term.²⁸ Autocorrelation of up to three lags was accommodated within our models, per the results of the Cumby-Huizinga general test for time series autocorrelation.^{29,30} Overall trends across the periods defining the Ebola virus disease outbreak and after the outbreak were calculated as follows: linear trend during the outbreak = $\beta_1 + \beta_3$; and linear trend after the outbreak = $\beta_1 + \beta_3 + \beta_5$. Differences were considered statistically significant at $p < 0.05$. The monthly data from each facility were entered centrally by the study team into EpiData 3.1 software and then imported into Stata v.14 for analysis.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

1676 cases of Ebola virus disease occurred within the health districts that we analysed from March, 2014, to February, 2015, resulting in an incidence rate of 9.6 per 10 000 person-years. The population covered by the included facilities was 94% of the regional total, and 99% of the cases of Ebola virus disease. In the months before the Ebola virus disease outbreak (January, 2013 to February, 2014), all three maternal indicators showed a significantly positive trend, ranging from a monthly average increase of 61 institutional deliveries (95% CI 38–84) to a monthly average increase of 119 women achieving at least three antenatal care visits (79–158; figure 2, table 2). Immediately after the onset of the outbreak in March, 2014, the number of women achieving at least one antenatal care visit marginally decreased, and no significant changes in level were noted in the number of women achieving at least three visits or institutional deliveries. However, the increasing trends seen before the outbreak were significantly reversed for all three maternal indicators during the outbreak (March, 2014, to February, 2015) (figure 2); on average, fewer institutional deliveries occurred (–240, 95% CI –293 to –187) and fewer women achieved at least one antenatal care visit (–418, 95% CI –535 to –300) or at least three antenatal visits (–363, 95% CI –485 to –242) per month ($p < 0.0001$ for all; table 2). Overall, the observed trends in antenatal care visits and institutional deliveries over the outbreak significantly declined for all three maternal indicators (table 2).

Immediately after the Ebola virus disease outbreak ended in March, 2015, we noted significant increases in the number of institutional deliveries and women attending at least one antenatal care visit (table 2). Compared with the negative trend during the outbreak, the change in trend during the post-outbreak period (March, 2015, to February, 2016) showed

that on average, 173 more women per month had at least one antenatal care visit (95% CI 51–294; $p=0.0074$) 257 more had at least three antenatal care visits (95% CI 117–398; $p=0.0010$), and 149 more had institutional deliveries (95% CI 91–206; $p<0.0001$). The overall trend during the post-Ebola period represented a significant decline for the number of women attending at least one antenatal care visit (–136, 95% CI –231 to –40; $p=0.0075$) but the post-outbreak trends for at least three visits and institutional deliveries were not significantly different from zero. Additionally, the trends for all three seemed to stagnate (appendix)

Before the outbreak (in January, 2013), the number of children younger than 12 months who had completed each vaccination ranged from 5752 (95% CI 2821–8682) for BCG to 8043 (95% CI 7621–8464) for yellow fever (table 3). We observed a significantly increasing trend in vaccination completion for all vaccines during the pre-outbreak period (January, 2013, to February, 2014; figure 3, table 3). Immediately after the onset of the outbreak (March, 2014), significant reductions occurred in the levels of all vaccinations except for yellow fever for which the reduction was marginal. The greatest reductions were noted for polio and BCG at –3594 (95% CI –4811 to –2377; $p<0.0001$) and –3048 (–5879 to –216; $p=0.036$) fewer vaccines administered, respectively (table 3).

Compared with the pre-outbreak trends, significant decreases occurred for all vaccines except polio, with the trend of monthly decreases in the number of children vaccinated ranging from –419 (95% CI –683 to –155) fewer for BCG to –313 (95% CI –446 to –179; $p<0.0001$) fewer for pentavalent during the outbreak (March, 2014, to February, 2015). Immediately after the end of the outbreak (March, 2015), the difference in vaccination coverage was not significantly different from zero for all vaccinations. Compared with the monthly trend in vaccinations during the outbreak, the monthly trend after the outbreak (March, 2015, to Feb, 2016) largely remained unchanged (BCG, polio, measles, and yellow fever), and the trend in the number of children vaccinated with pentavalent significantly increased by 154 (95% CI 10–299) per month on average. During the post-outbreak period, most monthly child vaccination levels showed either a significant declining trend (polio, measles, and yellow fever) or a numerical but non-significant declining trend (BCG and pentavalent). Overall, we recorded more vaccine stock ruptures in the post-outbreak period compared with the period during the outbreak, and more rupture in the period during the outbreak compared with the pre-outbreak period (appendix).

Discussion

We noted significant reductions in the average numbers of antenatal care visits and institutional deliveries per month during the Ebola virus disease outbreak, and despite the negative trend halting after the outbreak, the overall post-outbreak trends did not suggest recovery. Several possible explanations exist for this finding. First, the scientific literature suggests that the persistent reduced demand for maternal health-care services might have been a result of community mistrust of health-care systems and personnel during the Ebola virus disease outbreak.^{9,10} Second, although no further transmissions took place in the Forest region after March, 2015, awareness of the ongoing transmission elsewhere in Guinea, Sierra Leone, and Liberia might have influenced health seeking and provision

behaviours, especially the knowledge of continuous transmission of Ebola virus disease in health-care workers and persisting low infection-prevention measures.^{18,31–33} Third, the desertion of health facilities by health-care workers because of fear of the disease might have limited service provision. Fourth, because resources were directed towards controlling the outbreak, a shortage of road maintenance and frequent controls by security forces could have limited access to health facilities.

Similar to our maternal health findings, we noted significantly increasing trends in the numbers of children younger than 12 months receiving all five of the vaccination indicators before the outbreak. Significant negative trends were noted across the outbreak period for all vaccinations except for polio, and significant negative trends in the average number of children achieving vaccination persisted in the post-Ebola virus disease period for polio, measles, and yellow fever, and did not recover for BCG or pentavalent. Our finding that polio vaccine coverage remained stable during the outbreak period after an initial drop immediately after the onset of the outbreak could be accounted for by three polio vaccine mass campaigns undertaken in 2013 (before the outbreak) and four campaigns undertaken between March, 2015, and January, 2016, (after the outbreak) within the study region. Another reason is that polio vaccine is given orally, and thus might have been more acceptable to parents than the intramuscular vaccines because of concerns of Ebola virus disease transmission. Our finding that the negative trends for BCG and pentavalent did not persist after the outbreak finished whereas the other vaccinations did might be explained by the observed data overlaid by the fitted lines (appendix), which suggests that the negative trends observed through December, 2015, were attenuated by inclusion of substantial increases in the number of BCG vaccines in January and February, 2016.

These observed reductions and stagnations will have significant detrimental effects on child health over the coming years, as has been anticipated by authors of other studies.³⁴ Our preventive care findings contrast with a rapid rebound for treatment visits reported by Morse and colleagues³⁵ in Monrovia, Liberia, whose study showed a 77% relative increase in health-care provider visits for sick children in the early post-outbreak to late-crisis periods. These disparate findings might potentially be due to contextual differences or because the rationale for health-care seeking behaviour in the context of Ebola virus disease differed by prevention versus treatment, among others.

Our findings suggest that up to March, 2016, the essential maternal and child health services that were reduced due to both supply and demand factors associated with the Ebola virus disease outbreak have not recovered to their pre-outbreak rates, nor are they currently on a course that suggests that they will recover without significant and targeted interventions. Although we are unable to differentiate between the several likely drivers of these trends on the basis of our analyses, the findings from other studies suggest that even in areas where few cases of Ebola virus disease occurred and where health facilities did not close during the outbreak, up to 30% lower odds of facility-based deliveries were noted.^{15–17} The results from a population-based study by Ly and colleagues¹⁶ in Liberia have also shown that the belief that health facilities are or might be a source of Ebola transmission was significantly associated with a reduction in institutional delivery (adjusted odds ratio 0.59, 95% CI 0.36–0.97; $p=0.038$). These findings call for strong and targeted interventions to restore

community trust and build strong community–facility partnerships, and to improve the availability of human resources for health and the quality of health services. Only robust interventions involving communities will bring back the positive trend that maternal and child health services had in the region before the Ebola virus disease outbreak and secure the health of the maternal and child populations in areas most affected by the disease in Guinea and west Africa.

To our knowledge, our study is the first to quantify the trends in maternal and child health services received at the public facility level and explore the effect of the Ebola virus disease outbreak in a region of Guinea that was heavily affected by the disease. Although our sample cannot be considered fully representative of the Forest region, it is quite comprehensive because the population covered by the included facilities was 94% of the regional total, and 99% of the cases of Ebola virus disease.

Our results must be interpreted taking into consideration several limitations. First, routine data were used, and even though data were extracted using standardised forms and trained data collectors who were unaffiliated with the facilities, the possibility of data collection errors cannot be excluded. Second, because providers, data clerks, and surveillance officers were busy with the Ebola virus disease response, the record keeping might have deteriorated. Third, we defined our distinct periods of pre-Ebola virus disease, during Ebola virus disease outbreak, and post-Ebola virus disease on the basis of actual incidence of cases within the Forest region. Although the first case officially reported in the country was in the Forest Region, thus providing consistency with the rest of the country in defining the beginning of the epidemic, the last case noted in the Forest region occurred on Feb 25, 2015, whereas the official end of the Ebola virus disease epidemic for the countries of Guinea and Liberia was declared on June 1, 2016, and for Sierra Leone on March 17, 2016.^{36–38} Fourth, the method of interrupted time series analysis was done with aggregated data, thus no cross-district heterogeneity was explored. Fifth, the few observations within each defined period precluded fitting a more complex model despite the data for some indicators suggesting achievement of a local minimum level midway through the outbreak period, resulting in a more conservative estimate of trend decline in service use during the epidemic. Further exploration of the functional form of health-service reduction as the epidemic unfolded would be of interest. Sixth, we explicitly chose not to translate the service numbers captured into proportions of target population. Although general population numbers are designated for each health district, actual usage patterns might differ, and, therefore, we are not able to comment on how these trends translate into met and unmet needs at the population level. Finally, the assumptions of our method included that no other intervention or event occurred concurrently with the epidemic that would have affected the service trends that we noted.

In conclusion, the findings from our study showed that most maternal and child health indicators significantly declined during the Ebola virus disease outbreak, and that despite a reduction in these negative trends in the post-outbreak period, the overall post-outbreak trends did not indicate recovery in the Forest region of Guinea. Returning these services to a positive trend requires targeted interventions that rebuild trust between communities and the health system, investment in human resources for health, and improvement of the quality of

health-services provision. Future research is needed to define the content and assess the effect of such interventions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Research in context

Evidence before this study

Few studies have investigated the effect of the 2014 Ebola virus disease outbreak on maternal and child health services in west Africa. We searched PubMed and Google Scholar with no language restrictions for articles published up to Oct 7, 2016, with the terms “effects”, “impacts”, “consequences”, “Ebola”, “maternal”, “child”, “health”, “services”, “West Africa”, “Guinea”, “Sierra Leone”, and “Liberia”. We found five original studies reporting on the effects of Ebola virus disease on maternal and child health services in west Africa. The major finding was a decrease in facility-based deliveries, proportions of caesarean deliveries, antenatal care, and outpatient visits during the period of Ebola virus disease outbreak compared with the period before Ebola virus disease. However, all studies focused only on the periods before and during the outbreak and mostly used data from small samples. Additionally, these studies did not present comprehensive data on the different components of maternal and child health services such as immunisation services.

Added value of this study

Our study fills an important evidence gap and is the first study in Guinea and west Africa to use a comprehensive dataset from a region that was severely affected by Ebola virus disease to analyse the trend of maternal and child health services before, during, and after the outbreak. Our findings are that the utilisation rates of essential maternal and child health services have not recovered to their pre-outbreak levels, nor are they all on a course that suggests that they will recover without targeted interventions. The results help to understand how maternal and child health services have evolved during and after the outbreak and provide evidence to guide post-Ebola virus disease interventions.

Implications of all the available evidence

Combining evidence from this study with existing evidence suggests that the Ebola virus disease outbreak had significant negative effects on maternal and child health indicators in west Africa. Overall, the positive trends observed in all maternal and child health indicators before the outbreak were reversed with the epidemic. Additionally, the expected recovery in the trend for all maternal indicators after the outbreak did not occur and during the post-Ebola virus disease period the numbers for most child vaccinations continued to decline. These findings call for targeted interventions to improve the health of mothers and their children in the countries most affected by Ebola virus disease. Further research is needed to document the effect of current and further interventions.

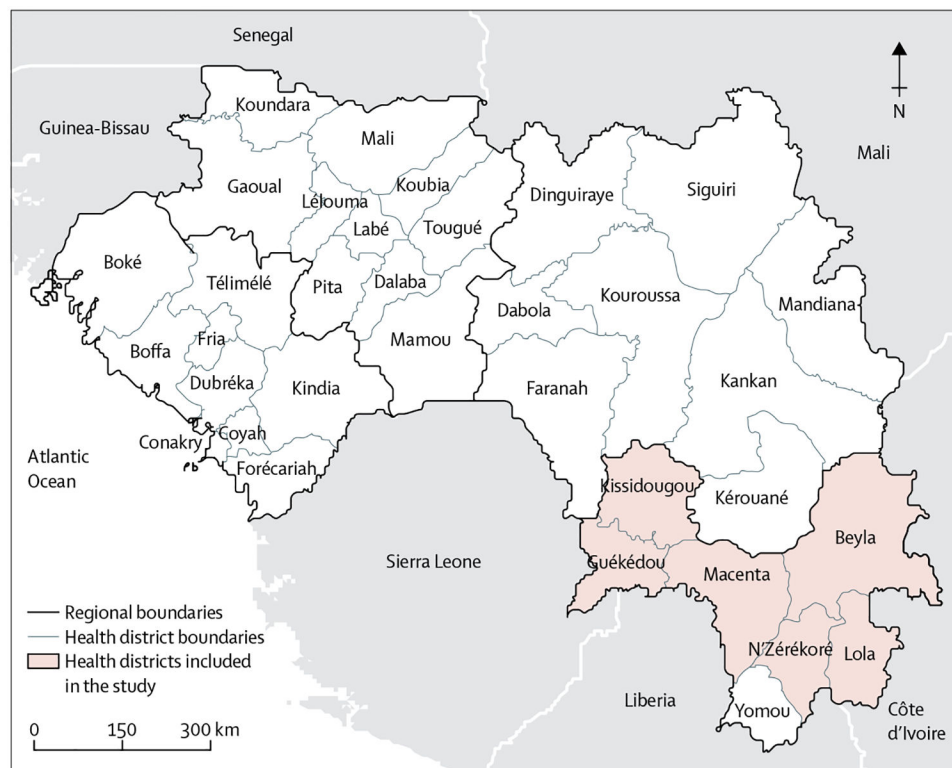


Figure 1:
Health districts in the Forest region, Guinea, included in the study

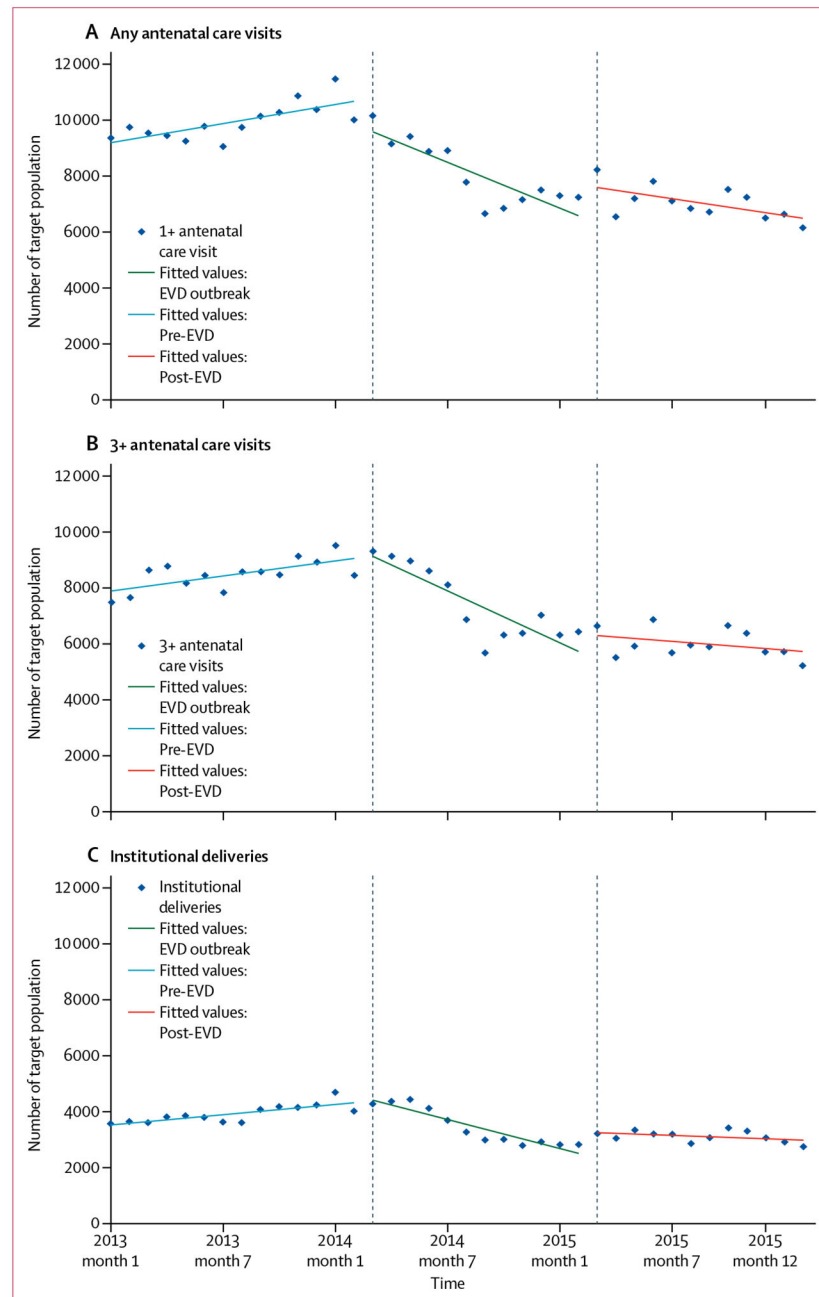


Figure 2: Number of women receiving at least one or at least three antenatal care visits and number giving birth in a health facility, Forest region, Guinea from January, 2013, to February, 2016

EVD=Ebola virus disease.

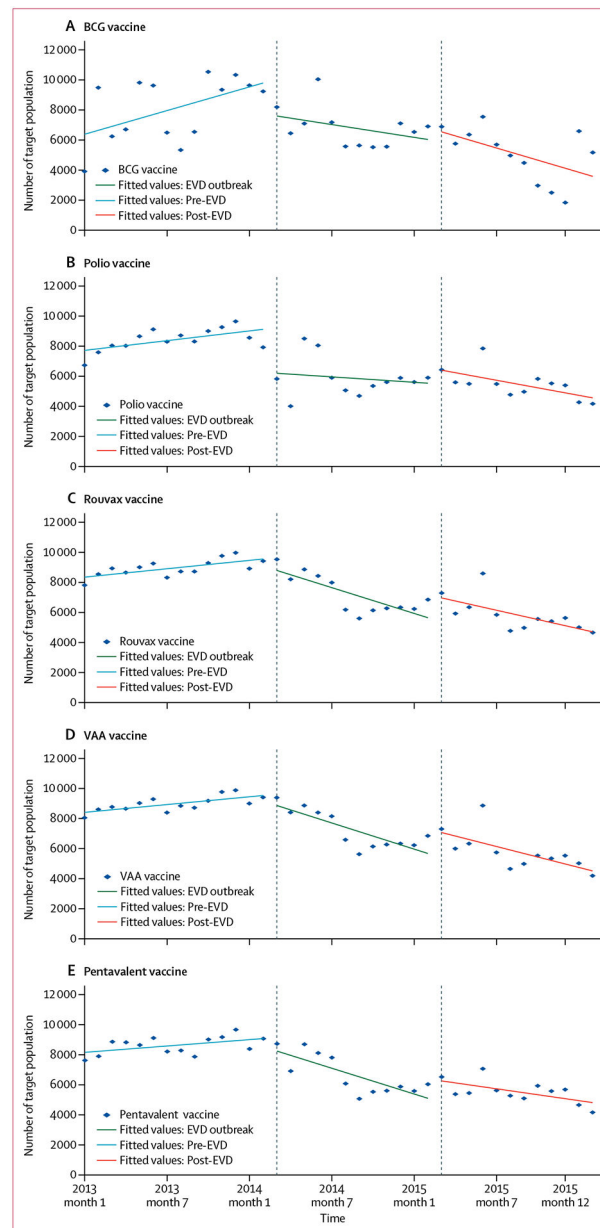


Figure 3: Number of children younger than 12 months covered by vaccines, in the Forest region, Guinea from January, 2013, to February, 2016

Vaccines analysed were BCG (anti-tuberculosis vaccine), pentavalent(a combination of five vaccines in one: diphtheria, tetanus, pertussis, hepatitis B virus, and Haemophilus influenzae type b), poliovaccine, Rouvax (anti-measles vaccine), and anti-amaril [yellow fever] vaccine). EVD=Ebola virus disease.

Table 1:

Demographic characteristics of the study population by health district

| | Total population in 2014 | Children aged <12 months | Antenatal care target (number of women) | Ebola virus disease cases | Ebola virus disease incidence* |
|-------------|-------------------------------------|--|--|--------------------------------------|---|
| Beyla | 326 082 | 13 043 | 14 674 | 47 | 1.4 |
| Gueckédou | 290 611 | 11 624 | 13 077 | 382 | 13.1 |
| Kissidougou | 283 778 | 11 351 | 12 770 | 136 | 4.8 |
| Lola | 171 561 | 6 862 | 7 720 | 111 | 6.5 |
| Macenta | 278 456 | 11 138 | 12 531 | 744 | 26.7 |
| N'zerekore | 396 949 | 15 878 | 17 863 | 256 | 6.4 |
| Total | 1 747 437 | 69 897 | 78 635 | 1 676 | 9.6 |

* Per 10 000 person-years during March, 2014–February, 2015.

Parameter estimates for monthly maternal indicators in the Forest region, Guinea, from January, 2013, to February, 2016

Table 2:

| | At least one antenatal care visit | | | Three or more antenatal care visits | | | Institutional deliveries | | |
|--|-----------------------------------|----------------|---------|-------------------------------------|---------------|---------|--------------------------|--------------|---------|
| | β | 95% CI | p value | β | 95% CI | p value | β | 95% CI | p value |
| Number of women using service at beginning of pre-Ebola Period (β_0) | 9568 | 8941 to 10 195 | <0.0001 | 7555 | 7098 to 8012 | <0.0001 | 3602 | 3345 to 3859 | <0.0001 |
| Average monthly change in number using service over pre-Ebola period (β_1) | 109 | 54 to 164 | 0.0005 | 119 | 79 to 158 | <0.0001 | 61 | 38 to 84 | <0.0001 |
| Average monthly change in number using service during Ebola virus disease outbreak (β_2) | -923 | -1882 to 36 | 0.0585 | -624 | -1568 to 320 | 0.1834 | 72 | -333 to 476 | 0.7163 |
| Difference between trend in service use during Ebola virus disease outbreak compared with pre-disease period (β_3) | -418 | -535 to -300 | <0.0001 | -363 | -485 to -242 | <0.0001 | -240 | -293 to -187 | <0.0001 |
| Average monthly change in number using service during post-Ebola period (β_4) | 1712 | 357 to 3066 | 0.0157 | 103 | -1385 to 1590 | 0.8871 | 982 | 362 to 1602 | 0.0034 |
| Difference between trend in service use during post-Ebola period compared with outbreak period (β_5) | 173 | 51 to 294 | 0.0074 | 257 | 117 to 398 | 0.0010 | 149 | 91 to 206 | <0.0001 |
| Overall trends | | | | | | | | | |
| Linear trend during outbreak ($\beta_1 + \beta_3$) | -309 | -428 to -189 | <0.0001 | -244 | -369 to -119 | 0.0006 | -179 | -233 to -125 | <0.0001 |
| Linear trend after outbreak ($\beta_1 + \beta_3$ plus β_5) | -136 | -231 to -40 | 0.0075 | 13 | -109 to 134 | 0.8286 | -30 | -80 to 20 | 0.2294 |

Data are from the segmented ordinary least-square regression model adjusted for birth seasonality. p value tests the null hypothesis that each of the coefficients is equal to zero, following the model specification and description in the methods section.

Table 3: Parameter estimates for monthly childhood vaccinations in the Forest region, Guinea, from January, 2013, to February, 2016

| | BCG | | | Pentavalent | | | Polio | | | Measles | | | Yello wfever | | |
|---|---------|---------------|---------|-------------|---------------|---------|---------|----------------|---------|---------|---------------|---------|--------------|--------------|---------|
| | β | 95% CI | p value | β | 95% CI | p value | β | 95% CI | p value | β | 95% CI | p value | β | 95% CI | p value |
| Number of childhood vaccinations at beginning of pre-Ebola period (β_0) | 5752 | 2821 to 8682 | 0.0005 | 7498 | 7154 to 7841 | <0.0001 | 6953 | 6380 to 7526 | <0.0001 | 7788 | 7443 to 8133 | <0.0001 | 8043 | 7621 to 8464 | <0.0001 |
| Average monthly change in number of vaccinations over pre-Ebola period (β_1) | 321 | 58 to 584 | 0.0193 | 93 | 50 to 136 | 0.0002 | 118 | 47 to 190 | 0.0025 | 119 | 53 to 185 | 0.0012 | 106 | 44 to 167 | 0.0017 |
| Average monthly change in number of vaccinations during Ebola virus disease outbreak (β_2) | -3048 | -5879 to -216 | 0.0362 | -1483 | -2469 to -497 | 0.0051 | -3594 | -4811 to -2377 | <0.0001 | -1328 | -2474 to -182 | 0.0252 | -1075 | -2158 to -7 | 0.0514 |
| Difference between trend in vaccinations during Ebola virus disease outbreak compared with pre-disease period (β_3) | -419 | -683 to -155 | 0.0034 | -313 | -446 to -179 | <0.0001 | -108 | -276 to 61 | 0.1976 | -357 | -483 to -231 | <0.0001 | -363 | -488 to -238 | <0.0001 |
| Average monthly change in number of vaccinations during post-Ebola period (β_4) | 128 | -2776 to 3031 | 0.928 | 655 | -1009 to 2320 | 0.422 | 76 | -1145 to 1297 | 0.898 | 1024 | -516 to 2565 | 0.481 | 1295 | -245 to 2835 | 0.095 |
| Difference between trend in | -127 | -328 to 73 | 0.2014 | 154 | 10 to 299 | 0.0373 | -107 | -262 to 47 | 0.1630 | 81 | -27 to 189 | 0.1338 | 58 | -57 to 172 | 0.3056 |

| | BCG | | | Pentavalent | | | Polio | | | Measles | | | Yello wfever | | |
|---|---------|-------------|---------|-------------|-------------|---------|---------|-------------|---------|---------|-------------|---------|--------------|-------------|---------|
| | β | 95% CI | p value | β | 95% CI | p value | β | 95% CI | p value | β | 95% CI | p value | β | 95% CI | p value |
| vaccinations during post-Ebola period compared with outbreak period (β_5) | | | | | | | | | | | | | | | |
| Overall trends | | | | | | | | | | | | | | | |
| Lineartrend during outbreak ($\beta_1 + \beta_3$) | -99 | -332 to 135 | 0.3899 | -220 | -3 63 to-77 | 0.0042 | 11 | -139 to 161 | 0.8841 | -238 | -371 to-105 | 0.0013 | -258 | -391 to-125 | 0.0006 |
| Lineartrend after outbreak ($\beta_1 + \beta_3 + \beta_5$) | -226 | -520 to 68 | 0.1251 | -66 | -201 to 70 | 0.3248 | -97 | -179 to-14 | 0.0240 | -157 | -249 to-65 | 0.0018 | -200 | -298 to-102 | 0.0004 |

Data are from the segmented ordinary least-square regression model. BCG=Bacille Calmette-Guerin (anti-tuberculosis vaccine). p value tests the null hypothesis that each of the coefficients is equal to zero, following the model specification and description in the methods section.